4.8 GEOLOGY

This section identifies potential impacts related to geology, seismic conditions, and soils within Ames Research Center from each of the five alternatives, and proposes mitigation measures to reduce or eliminate identified impacts.

A. Standards of Significance

An alternative for the NASA Ames Development Plan (NADP) would have a significant impact with regard to seismic safety and geology if it would:

- Result in major changes to the topography of Ames Research Center.
- Expose buildings or people to unusually high levels of geotechnical or seismic hazard.

B. Impact Discussion

This section discusses potential impacts on seismic safety and geology from each of the five proposed alternatives. As discussed in Section 3.8 of this EIS, the principal sources of seismic and geotechnical hazards within Ames Research Center are large future earthquakes and ground subsidence. The soils within Ames Research Center also present risks of differential settlement.

1. Topography

As described in Section 3.8 of this EIS, the topography at Ames Research Center is almost entirely flat. The only significant topographical features are the man-made berms along Stevens Creek and the edge of the wetlands in the North of Bay View area.

Under Alternatives 2, 4 and 5, there would be a substantial amount of fill placed in low-lying portions of the Bay View area. As noted in Chapter 2, Section 2.B.2.g, fill would be required to bring the finished grade up to 2 meters (7 feet) along the northern edge of the Bay View area, and to slope the rest of that area upward to the south to conform to the existing ground at higher elevations. This would require fill over a 278,700 square meter

(3,000,000 square foot) area with fill ranging in depth from 0.15 meters to 1.40 meters (0.5 feet to 4.5 feet), with an average depth of 0.6 meters (2.0 feet). The total volume of fill required would be approximately 170,000 cubic meters (220,000 cubic yards). There would also be some minor grading associated with development in all four planning areas. This is not considered a significant impact since all fill would be engineered when placed.

2. Seismic and Other Geotechnical Hazards

There are no known active faults within Ames Research Center, so there is little possibility of ground-surface rupture. However, the Center is located in close proximity to three active faults. Plausible seismic hazards at Ames Research Center thus include ground shaking, liquefaction, differential settlement, and lurch cracking. These are typical conditions within the San Francisco Bay Area.

Clayey soil is generally not considered susceptible to liquefaction, and dense sands have low susceptibility to liquefaction. A few layers of medium dense/medium stiff sandy and silty soils are interspersed within the clayey soil between depths of 4 and 14 meters (13 and 45 feet). In general, these layers are 5 feet in thickness, but can be as thick as 5 meters (17 feet). These sandy and silty layers could potentially liquefy during strong seismic shaking and result in settlement.

Assuming that all proposed new buildings would be founded on either mat foundations or shallow spread footing foundations because of high water table and contamination issues, it is estimated that the maximum total settlement would be less than 3.8 centimeters (1.5 inches), and the differential settlement about 2.5 centimeters (1 inch), at the ground surface after a moderate to strong earthquake.

As described in Section 3.8 of this EIS, ground subsidence due to decreasing groundwater levels is another potential geotechnical hazard at Ames Research Center. In the period between 1932 and 1969, ground subsidence caused the land at the Center to sink between 1.7 and 1.8 meters (5.5 and 6 feet). Due to

an aggressive recharge program implemented by the Santa Clara Valley Water District, groundwater levels have remained fairly stable over the last 30 years, but are still subject to seasonal fluctuations.

The silty clay soil within Ames Research Center presents two potential geotechnical issues, as described in Section 3.8 of this EIS. The soil is very malleable, which can lead to differential settlement around buildings. It also has a strong shrink-swell potential with seasonal fluctuations in moisture, which can stress shallow concrete slabs and pavement and cause cracking and heaving.

Alternatives 2 through 5 propose substantial quantities of new development, and all new buildings would be exposed to ground subsidence, differential settlement, and seismic hazards. This could create a significant impact if improper safety designs were implemented.

NASA and its consultants commissioned a preliminary study of potential safe building heights in the NRP area under known geotechnical conditions, which was completed by Geomatrix. Based on available subsurface information, Geomatrix found that the depth to the soft/medium stiff soil layer varies from 1.5 and 4.6 meters (5 to 15 feet) across the site. For areas where this depth is less than 2 to 3 meters (7 to 10 feet), it might not be appropriate to build higher than three stories and shallow spreading footing or mat foundations would be appropriate only for one- to two-story buildings and for some lightweight three-story buildings. For areas where the depth to soft/medium clay is greater than 3 meters (10 feet), Geomatrix found that buildings up to five stories tall could be supported on a mat foundation. The bottom of the mat foundations should be limited to a depth of 2 meters (5 feet) from the current grade.

More specifically, Geomatrix found that the NRP can be separated into four regions regarding the height of buildings that can be supported on shallow foundations, as shown in Figure 4.8-1.

— **Region 1: west of Bailey Road and south of Wescoat Drive.** Buildings in this area could be five stories high or even higher. However, sufficient subsurface information is not available in this region to be confident about using shallow foundations.

— **Region 2: north of Wescoat Road and south of Bushnell Road.** Buildings 2 to 3 stories high may be appropriate in this region. In the southern part of Region II, it is possible that buildings up to five stories could be supported on shallow foundations. However, there is not sufficient subsurface information available to confirm this.

— **Region 3: east of Bailey Road, south of Wescoat Drive, west of Ellis Street.** Buildings of five stories high would be appropriate in Region III.

— **Region 4: East of Ellis Street.** Buildings of 2 to 3 stories would be appropriate in this region. Buildings five stories high might be possible.

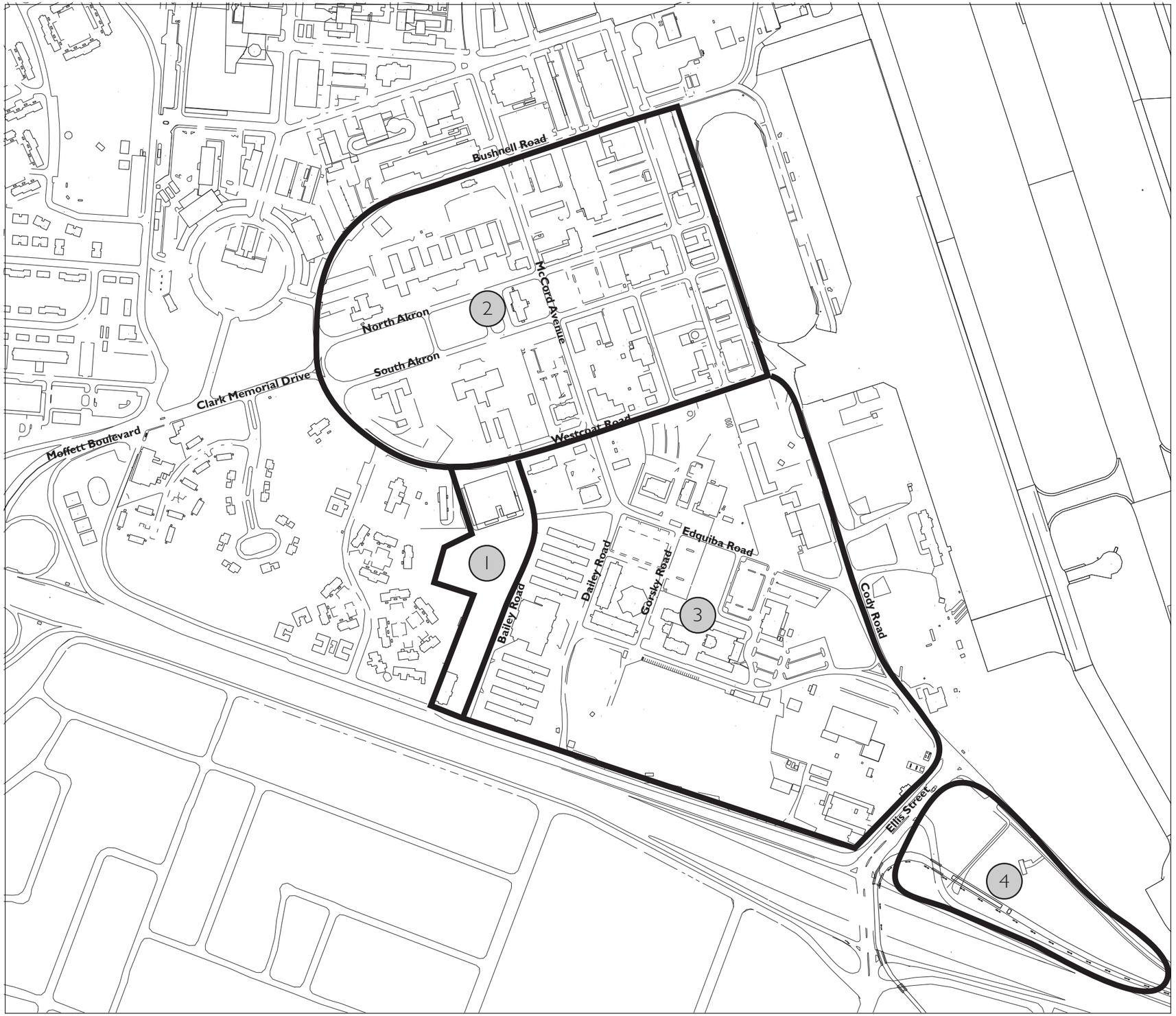
Preliminary studies indicate that it would be possible to safely construct the types of buildings foreseen under all proposed alternatives. Based on borings from the area north of N258[1], similar soils close to Bay View would be adequately buildable. However, no further analysis of on-site conditions has been undertaken. Geotechnical investigations would be needed before individual buildings could be constructed.

Under all of the development alternatives, a number of existing structures at Ames Research Center would be rehabilitated and reused. To the extent that these existing structures do not meet current Uniform Building Code seismic standards, future employees could be exposed to seismic and other geologic hazards, which would be a significant impact.

[1] Harding Lawson Associates. Geotechnical Investigation: Computer Research Facility Expansion, NASA-Ames Research Center, Moffett Field, CA. May 10, 1990.

FIGURE 4.8-1

APPROPRIATE BUILDING HEIGHTS BASED ON SUBSURFACE SOIL CONDITIONS



1 5 Stories or Higher

2 2- 3 Stories

3 5 Stories

4 2-3 Stories

N

0 28m 56m 113m

0 93ft 185ft 370ft

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3. Cumulative Impacts

Geotechnical impacts occur on a site-by-site basis and are not exacerbated by multiple developments occurring in proximity to one another. Therefore, the cumulative projects listed in Chapter 2 would not combine with the NADP to generate cumulative geotechnical impacts.

C. Impacts and Mitigation Measures

This section summarizes significant impacts identified in Section B, and proposes mitigation measures for each identified impact.

Impact GEO-1: Many of the existing buildings that would be rehabilitated and reused do not meet current seismic safety standards.

Applicable to: Alternatives 2 through 5, and Mitigated Alternative 5

Mitigation Measure GEO-1: All rehabilitation of historic structures within the Shenandoah Plaza Historic District would follow the Guidelines for the Rehabilitation of Historic Structures developed by the Architectural Resources Group for NASA and within the Ames Campus would follow the Secretary of the Interior Guidelines for the rehabilitation of Historic Structures in order to maximize seismic safety while minimizing effects on the integrity of any structure on or eligible for the National Register of Historic Places.

Impact GEO-2: As is the case throughout the San Francisco Bay Area, new buildings, as well as the employees, residents, and visitors that use them, would be exposed to seismic hazards.

Applicable to: Alternatives 2 through 5, and Mitigated Alternative 5

Mitigation Measure GEO-2: All new buildings at Ames Research Center would be designed to meet the current Uniform Building Code regulations for seismic safety.

Impact GEO-3: As is the case throughout the Santa Clara Valley, new buildings could be exposed to structural hazards from ground subsidence. Also, because almost all of Ames Research Center sits on silty clay soils, new buildings would be exposed to geotechnical hazards such as differential settlement around buildings, and to cracking and heaving. The maximum height of proposed buildings would depend on several factors, including the depth to pockets of soft/medium stiff clayey soil, the thickness of surficial stiff crust, and the thickness of soft/medium stiff clay.

Applicable to: Alternatives 2 through 5, and Mitigated Alternative 5

Mitigation Measure GEO-3: All new construction would be designed based on geotechnical analyses of proposed sites to determine the structural measures necessary to counter the shrink-swell potential of the soil and the risk of structural damage from ground subsidence.

Impact GEO-4: Detailed geotechnical studies have yet to be completed for most of the potential building sites at Ames Research Center. While preliminary studies indicate that it would be possible to safely construct the types of buildings foreseen for all planning areas under any of the alternatives, there may be specific geotechnical hazards on individual sites that require mitigation when construction occurs.

Applicable to: Alternatives 2 through 5, and Mitigated Alternative 5

Mitigation Measure GEO-4: Prior to construction of individual facilities, NASA and its partners would conduct detailed geotechnical investigations of all proposed building sites, and would incorporate the engineering recommendations of these studies into building design and construction.